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Provision of Broadband Video Conference via IN and B-ISDN Integration: Architectural and Modelling Issues

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Abstract

This paper deals with the integration between the Intelligent Network (IN) and the B-ISDN for the support of an advanced multimedia service, i.e. the Broadband Video Conference (B-VC). The focus of the paper is the proposal of a new role of the IN that, in a closed interaction with the B-ISDN, furnishes control functionality to handle complex service configuration.

In order to assign such a role, we distinguish different levels of control into the IN architecture and we propose functional models able to represent, at each level, a specific service view, suitable to th IN, and cooperating for a global service provisioning.

Some different options for an IN/B-ISDN interaction are discussed; in particular, the architectural aspects of a solution distributing the IN control logic between the Service Control Function (SCF) and the Service Switching Function (SSF) are described in details.

Finally we consider an actual multimedia service, the Broadband Video Conference, supported with the proposed approach, and we analyse the relevant performance behaviour.

Keywords

IN and B-ISDN, multimedia services, IN architecture.

1   INTRODUCTION

The growing user needs and the emerging advanced computer applications require, in addition to networks with high bandwidth capabilities, a powerful signalling system able to manage and to coordinate sophisticated network configuration scenarios.

Up to now the standardisation bodies have defined two B-ISDN signalling protocol releases: the Signalling Capability Set 1 (SCS 1) and Signalling Capability Set 2 (SCS 2) [ITU-T Q.2931, 1994] [ITU-T Q.2971, 1994].

The SCS 1 supports simple switched services consisting of single-connection, bi-directional, point-to-point calls. The objective of SCS 2 was the handling of: multiparty calls, several connections in a single call, correlation among different media, heterogeneous terminals and dynamic change of call topology and connections parameters. This wide objective suggested to split the signalling protocol definition activity in steps. The first step gave rise the SCS 2.1, that is, at present, the unique stable signalling capability set. The main innovation within SCS 2.1 is the point-to-multipoint connection handling.

Unfortunately, there still exists a remarkable gap between the standardised B-ISDN control capabilities and the requirements of new telecommunication services based on multipoint-to-multipoint call configurations, as in the case of the Broadband Video Conference (B-VC). A solution to rapidly fill up this gap is the integration of the B-ISDN and the IN paradigms. This approach has been proposed in previous papers [Maastricht, 1995] [Wakamoto, 1995] [Mukasa, 1995] [Carmagnola, 1996] and is the focus of an European ACTS project, named INSIGNIA [AC068 INSIGNIA deliverables].

As well known, IN allows a flexible introduction of new capabilities, and facilitates and accelerates, in a cost effective manner, service implementation and provisioning in a multi-vendor environment. The flexibility of this paradigm mainly lies in the separation between the control functionality relevant to the transport plane and the ones relevant to the service provisioning.

The classical IN service provisioning is based on a direct interaction between the IN logic, implementing supplementary aspects of the service, and the bearer service furnished at the transport level [ITU Q.1211-Q.1218, 1995]. In the IN/B-ISDN integrated approach, the IN provides a platform to enrich the functionalities furnished by the B-ISDN, in order to realise the handling of several basic calls/connections in a coordinate manner, according to the service logic requirements [Cuomo, 1996].

Figure 1 represents a logical scheme showing how this new functionality, here called *Bearer Connections Coordinator* (BCC), is inserted within the integrated IN/B-ISDN functional architecture.

By considering the present B-ISDN signalling capabilities, the BCC must be entirely located in the IN domain. In the future, the growing of the B-ISDN signalling capabilities could bring a reduction of the functionalities realised in the

IN domain and a migration of some functions within the B-ISDN one. It is also to be noted that we refer to B-ISDN call and connection as a unique entity since, for the time being, they are handled at the B-ISDN level in a monolithic way.
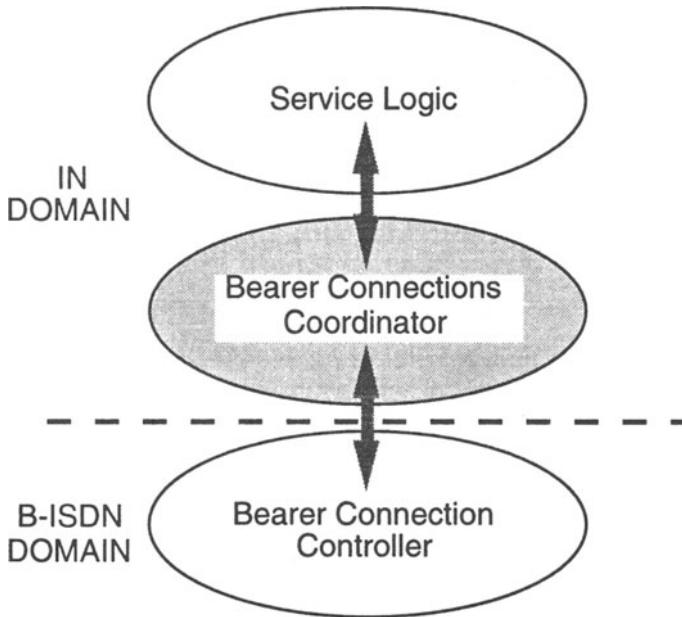
Figure 1 Functional organisation of the integrated IN/B-ISDN paradigm.

In this paper we discuss the functionality of the IN Bearer Connections Coordinator with particular reference to the provisioning of the Broadband Video Conference service. The solution here presented, derived from one of the main outcomes of the INSIGNIA project, foresees that the BCC functionality is shared between the Service Control Function (SCF) entity, located in the Service Control Point (SCP) and the Service Switching Function (SSF) entity, located in the Service Switching Point (SSP).

The coordination between the two entities is carried out by means of two service representation models: the former, named *Global Logic Service Configuration* (GLSC) is resident in the SCF; the latter, named *session*, is resident in the SSF.

This solution establishes a separation between the role of the SSF, that, according to the classical IN paradigm, furnishes functionalities independent of the specific service, and the role of the SCF that realises the service dependent functionalities. Moreover, as it will be described in the following, this solution allows a very efficient SCF/SSF interaction based on a high level service view. The SSF translates such a view into multiple views of lower level (i.e. the Basic

Call State Models - BCSMs), for the interaction with the B-ISDN control functionalities.

As a matter of example, in the second part of the paper, the proposed approach is applied for the provision of the Broadband Video Conference service, which requires very advanced control capabilities to handle the relevant network configuration.

The organisation of the paper is the following: Sec. 2 describes the functional levels in which the BCC is splitted and the relevant service representation models (i.e. the GLSC and the *session*). In Sec. 3 the IN approach is applied for the provision of the B-VC service, showing two architectural solutions. A brief performance evaluation is also carried out.

2   THE BEARER CONNECTIONS COORDINATOR IN THE IN DOMAIN

The fundamental requirement, in the design of an integrated IN/B-ISDN system architecture, is that different basic B-ISDN calls/connections have to be coordinated by the IN, in order to provide the required user plane configuration.

To this aim, in the framework of the INSIGNIA project, a functional architecture structured in four control domains has been developed [AC068 INSIGNIA Deliverable]: i) the *service control domain*, comprising the overall control of the IN service; ii) the *session control domain*, where the association of different B-ISDN calls for the realisation of a single IN service is handled; iii) the *call control domain* where each single B-ISDN call is controlled; iv) the *connection control domain*, where the physical switching resources involved in a B-ISDN call are controlled.

Figure 2 shows the relationships among these four domains and their mapping on the IN functional entities. Moreover, in the same figure, the two functional domains where the BCC functionality is implemented are singled out.
Within the service control domain, the BCC is responsible for the global service control and of the relevant network configuration; this goal is achieved by means of the interaction between the service logic inside the SCF, responsible of the service execution, and a high level representation of all the network components and of their relationships (GLSC).

As far as the session control domain is concerned, the BCC is dedicated to the control and the coordination of all the calls/connections supporting a specific service. By considering a single service instance, two main architectural solutions can be applied: i) a *centralised* approach, the session control function is located in a single SSF; ii) a *distributed* approach, the session control function is distributed among many SSFs.

### 2.1 The session control domain

The session control domain represents the lower level of coordination of basic B-ISDN calls/connections involved in the provisioning of a single service. As shown in Figure 2, the B-ISDN call/connections are modelled independently by

means of the classical BCSM inside *the Call Control Function* (CCF). The connection coordination is obtained by developing, within the *IN Switching Manager* (IN-SM) entity inside the SSF, an enhanced *Switching State Model* (SSM) to be offered to the SCF control [AC068 INSIGNIA Deliverable].

This enhanced model, indicated as *session*, is realised by means of a suitable object modelling, and it is the tool needed to represent the connections, parties and relationships involved in the service in a specific SSF.

The IN Switching Manager handles the call events reported by the BCSMs and correlates them in the context of a session by sending appropriate messages to the SCF. In the other direction, the IN SM receives commands from the SCF and sends appropriate messages to the BCSMs (Figure 2).

In the *centralised* approach, a single session comprises all the B-ISDN calls/connections involved in the service; this means that a single SSP controls the whole set of B-ISDN connections. This solution, especially in multiparty services, where the number of involved connections could be significant, gives rise to an inefficient resource utilisation, both from a transport and a control point of view.
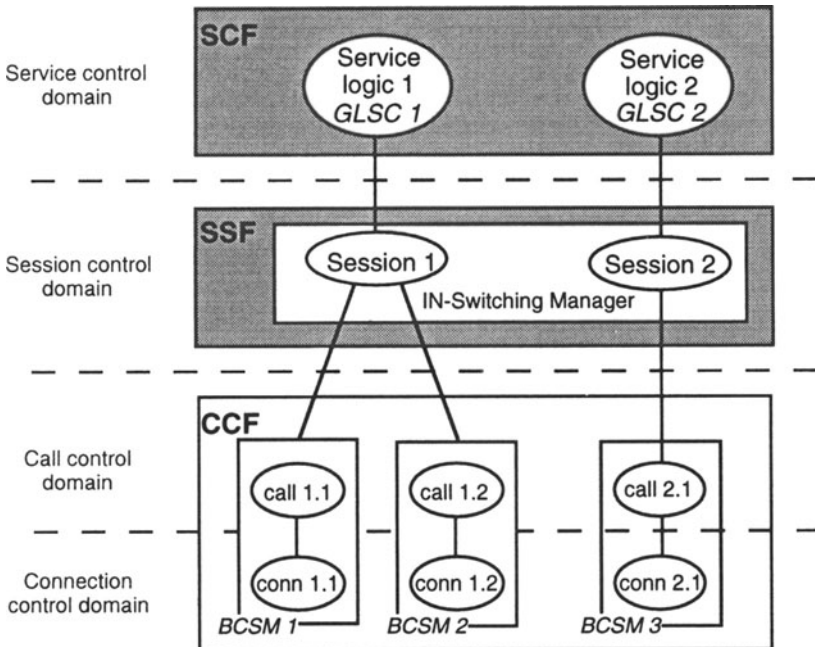
Figure 2 Control domains definition within IN/B-ISDN functional architecture.

A more suitable solution, the *distributed* one, foresees that, if needed, there could be more than one SSF involved in the same service instance. This means that the calls/connections composing the service configuration are controlled by different

SSPs. The controlling SSPs are selected with the aim of minimising the usage of the network resources.

The *distributed* solution implies that the session contained in each SSF represents only a partial view of the service configuration. The merging of these partial views is performed at the service control domain by the SCF.

To fully exploit the potentialities of the session concept, two new control capabilities are introduced within the session control domain:

1. *SCP-initiated call*; the SCP can order the SSP to set-up a call between two users (i.e. a point-to-point connection). This IN functionality supplies the "Third Party Call Initiated" procedure; in this procedure separate paths of a connection towards two remote users are set-up and linked by a third party. This functionality can also be used to set-up a point-to-multipoint connection among a root user and a multiplicity of leaf users. In this case, the root is connected to the SSP by means of a single unidirectional point-to-point connection, while the point-to-multipoint part of the connection starts from the SSP.

2. *SCP-session activation*; this command is used to activate a session (in a generic SSP) on behalf the SCP. This functionality allows the control of the connections involved in a service through a multiplicity of sessions distributed in several SSPs. It is to be noted that this capability differs from that used in the classical IN approach, where the activation of a SSM instance is always due to a user request.

The proposed object model of a session is shown in Figure 3. It contains objects that are abstractions of switching and transmission resources [AC068 INSIGNIA Deliverable].
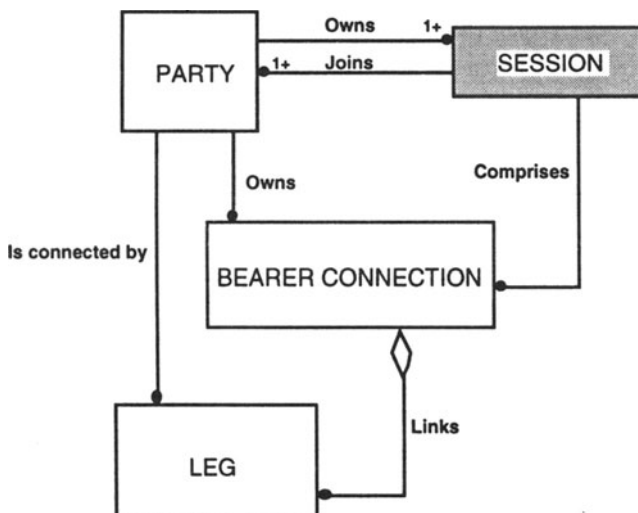
Figure 3 The session object model.

The *session* object represents the session instance. Several parties, represented by the *party* object, can join a session. A party can be either an end user or a network component (e.g. the SCP, when it is necessary to represent SCP-initiated actions). One of the parties joining a session is the session owner. During the service evolution, new parties can be added to a session or joined parties can be removed from a session.

The *bearer connection* object represents the bearer connection processing and is potentially in relationship with several legs. The *leg* object models the processing of the communication path towards a party. The multiplicity of the aggregations between the legs and a bearer connection determines the connection topology: if a bearer connection contains exactly two legs, it is a point-to-point connection; if there are more than two legs per bearer connection, we have a point-to-multipoint connection.

Moreover, each object could also be denoted by one or more attributes regarding some of its specific characteristics. In particular, we can distinguish static attributes and dynamic ones. The static attributes denote fixed characteristics of the object assigned in the active service instance. The dynamic attributes change during the service evolution and are used by the IN logic to follow the dynamic modifications of the service configuration.

The proposed model is a powerful tool to handle the interaction between the service control domain and the B-ISDN control function. It shows each single service component, the state reached by each of them and their relationships. Moreover, this model allows the utilisation of a high level language between the SCF and the SSF (i.e. an enhanced INAP protocol called B-INAP [AC068 INSIGNIA Deliverable]). As a matter of example, the SCF can command in a single interaction the dropping of a party; this implies that, at the SSF level, the object party is removed by the session, together with all its bearers and legs. To this aim, the SSF generates the appropriate messages towards all the BCSMs involved.

2.2 The service control domain

The service control domain realises the global handling of the service. The SCF, interacting with all the SSFs involved in the service, derives the overall network configuration by merging all the partial views represented by the single sessions.

The resultant model, called *Global Logic Service Configuration* is a high level one and it is designed to support the *Service Logic Instance* (SLI). It is worth noting that this model assumes fundamental relevance in case of a service realised adopting the *distributed* approach described above.

The GLSC is composed by four types of objects (Figure 4): i) the *GLSC* object, representing the active service instance; ii) the *session* object, identifying the session instance in each SSF involved in the service provisioning; iii) the *actor* object, representing either users or special resources (intelligent peripheral, bridge audio/video etc.) involved in the service; iv) the *stream* object, representing the information flow among actors.

The actor and the stream objects hold the main parameters needed by the SLI. The actor object contains user specific characteristics, like the E.164 address, and their role in the service (e.g. optional or mandatory). The stream attributes concern the frame structure of the flow (data format and coding, e.g. MPEG1, JPEG), the quality of service and throughput values. The stream direction could be indicated by an attribute assigned to the relationship "is connected to", said attribute assuming the values incoming, outgoing or both.

The GLSC object model allows the SLI to retrieve all the necessary data. Thank to this model, it is possible to identify the session controlling the stream that connects two or more actors; therefore, if an actor has to be excluded from the service, it is straightforward to discriminate the session that the actor has joined and, within the session, the streams to which the actor is connected to.

It is to be noted that the more sophisticated is the service network configuration, the more important is the role played by the GLSC. This happens, for instance, when a great number of special resources are involved or when the service provisioning is carried out by means of the interaction with several SSPs.
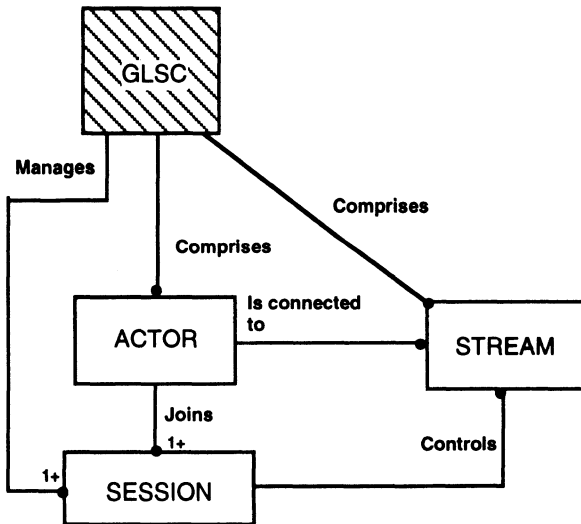
Figure 4 The GLSC object model.

2.3 Interactions between session and service domains

The typical interaction between the session domain and the service one (in the direction that goes from the former to the latter) is the following:
1. each event on the basic bearer connection is driven by the B-ISDN signalling and reported to the IN-SM by means of the *Detection Points* (DP) in the BCSM;

2. the IN-SM modifies, in accordance to the event reported, the state of one or more objects represented in the session instance (for instance, the dynamic attribute representing the state of the bearer connection can be modified from *being set-up* to *set-up*);
3. the new state of the session is reported to the SCF and it is processed by the SLI;
4. according to the state being reported, the SLI updates the GLSC state.

In the opposite direction (from the service domain to the session one), an interaction is needed when, during the service processing, the SLI requires the session domain to execute an operation or when a user asks the SCF to execute a service procedure.

The steps of this interaction are:
1. the SLI retrieves the service network configuration held in the GLSC;
2. according to the information obtained and to the service procedure requested, the SLI commands one or more SSFs to execute the appropriate operation, by means of enhanced INAP messages mentioned above;
3. the IN-SMs add new objects or modify the state of those already present in their session instances, and the SSFs command the underlying CCFs to carry out the requested operations.

3   THE BROADBAND-VIDEO CONFERENCE SERVICE

In this section we apply the IN approach to support a multimedia-multiparty service, the Broadband Video Conference (B-VC).

The B-VC is a telecommunication service which allows end-to-end information transfers between two or more service subscribers [EURESCOM P506,1995]. This service provides the necessary arrangements for a real-time conferencing in which audio, video, and other media types can be exchanged among single individuals (single workstations) or group of individuals (located in conference rooms) via the B-ISDN.

The provision of this service requires very powerful signalling capability to obtain and manage a fully meshed audio/video interconnection among all the subscribers, making the B-VC one of the more complex services to be offered by the B-ISDN.

3.1 Service description

The B-VC service is provided by means of an "on demand" mode. The service consists of the following classes of procedures [AC068 INSIGNIA Deliverable]:
- procedures applicable to a not yet existing conference: conference creation;
- procedures applicable to an inactive conference: inactive conference modification, conference establishment;

- procedures applicable to an active conference: addition of new conferee(s), disconnection of conferee(s), active conference modification, conference closing down.

The conference creation consists of a phase during which the user requiring the service, called hereafter *conference coordinator*, defines the conference profile: the media required, the list of users that could be involved and their profiles (e.g. role in the conference, procedures access rights, etc.). After the creation phase the conference can be activated immediately or later on.

During the inactive phase, the conference profile can be modified by the conference coordinator by means of the *inactive conference modification* procedure.

The *conference establishment* procedure allows the coordinator to start the active phase of the conference service; this procedure consist mainly in inviting the users and then in interconnecting them.

During the active phase of the conference a new conferee can be added to the service; this happens as a consequence of a request coming from an authorised conferee or directly from the new user. The coordinator can or can not accept this request. Of course, a conferee can leave an active conference anytime with the *disconnection of conferee* procedure (also, an authorised conferee can request the disconnection of another conferee).

The *active conference modification* procedure allows a user to request the coordinator to modify his/her profile; in addition the coordinator can use this procedure to indicate a possible new coordinator. Finally the conference closing can be obtained by means of the *conference closing down* procedure.

It is worth noting that the interaction between the users and the service logic can be supported by a *Specialised Resource Function* (SRF) located in a *Broadband Intelligent Peripheral* (B-IP); all the users are connected to this special resource via a data bearer and the B-IP interacts with the SLI by using the INAP protocol.

3.2 Service analysis

In this section we analyse the conference establishment procedure, realised both with the *centralised* architectural solution and with the *distributed* one, and compare the performance of the two approaches; we also study the resulting service representation models at the session domain and at the service domain.

The *centralised* approach is based on a relationship between a SCF and a single SSF. The latter is the SSF in which the conference coordinator has invoked the service logic.

The main steps to realise the service establishment are the following:

- the coordinator invokes, through a data bearer connected to the B-IP previously activated, the establishment procedure;
- the SCF sends to the SSP subsequent "SCP-initiated call" commands to realise a fully meshed interconnection of all the invited users;
- the SSF modifies the session view, orders the CCF to set-up the desired connections (bi-directional point-to-point or unidirectional point-to-multipoint) and reports the results to the SCF;

* the SCF updates the GLSC according to the reported results.

Figure 5 represents the network configuration in the centralised approach for a three users conference.

The connections of the users to the B-IP are not shown; for the sake of neatness only one type of connection (for example the video one) is represented. As depicted in this figure, all the connections have to cross a fixed SSP, where are coordinated in a single session instance. The grey arrows represent the interactions between each independent BCSM and the IN-SM handling that BCSM. This solution can be applied for both the SCS 1 (Figure 5a) and the SCS 2.1 (Figure 5b).

This approach can lead to a very inefficient use of the network resources when the users involved are spread in a wide geographic area and thus can be very distant from the SSP of the conference coordinator.

To overcome this impairment the *distributed* approach can be used (Figure 6). The *distributed* approach leads to a multiple interaction between the SCF and two or more SSFs. The SSPs are chosen so as to obtain an efficient resource utilisation. The algorithm that optimises the resource utilisation is implemented in the SCP that realises the distribution of the connections among the sessions; the SCP commands the creation of new sessions, in addition to that already present in the SSP where the conference coordinator has required the execution of the service. As shown in Figure 6a, the session 2 is created to handle the connections concerning users B and C.
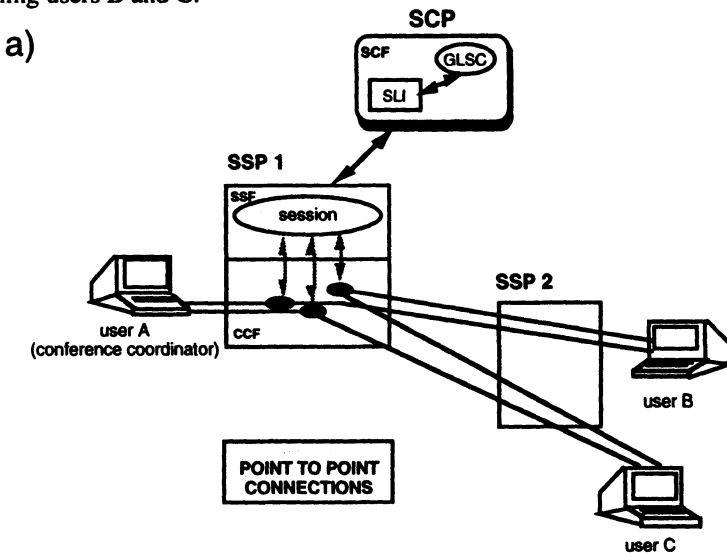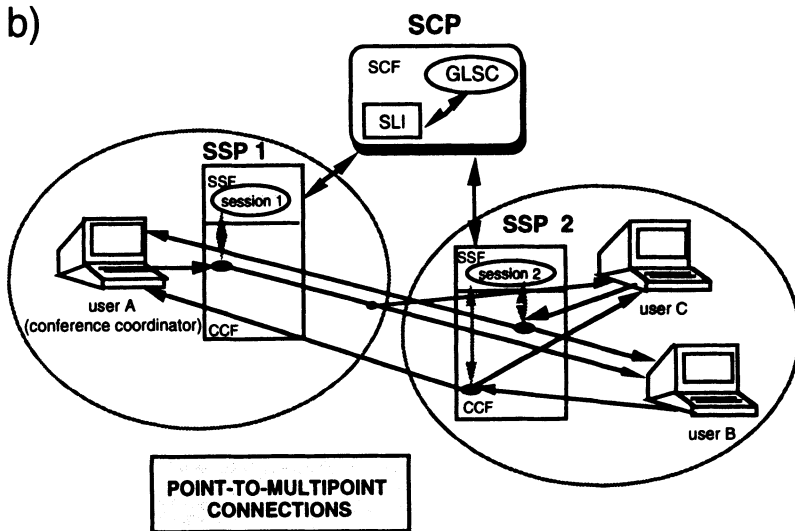

Figure 5a Network configuration in a centralised approach: case of point-to-point connections.

b)
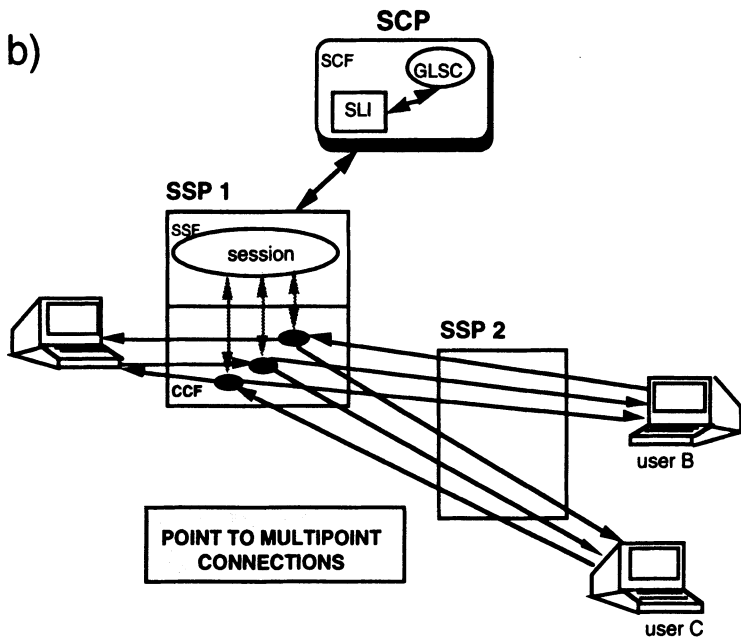
Figure 5b Network configuration in a centralised approach: case of point-to-multipoint connections.

a)
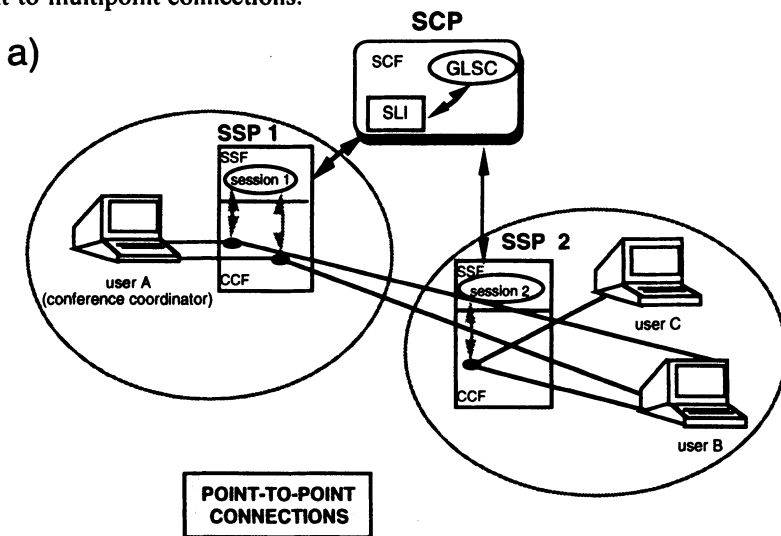
Figure 6a Network configuration in a distributed approach: case of point-to-point connections.

Figure 6b Network configuration in a distributed approach: case point-to-multipoint connections.

In order to compare the two approaches a performance study has been carried out. Two main aspects have been analysed: the signalling load on the network nodes and the transport resource utilisation.

Several network configurations with a variable number of SSPs and conferees have been considered. For a given network configuration we analysed all the possible associations between conferees and SSPs and the presence of a multiplicity of active conferences. Here only a snapshot of results is reported.

As far as the signalling load is concerned, we have analysed both the B-ISDN and the IN one. We have evaluated analytically the number of signalling messages handled by each network element during the realisation of the Video Conference control procedures. Such a number can be taken as a measure of the signalling load at the application level. With respect to the IN signalling load the performance study main results are the following:

- the application of the *distributed* approach does not increase in a significant way the total IN signalling load (just few messages more than the *centralised* approach, the ones required to create new sessions in the SSPs);
- the application of the *distributed* approach allows to reduce the processing load per SSP;
- the utilisation of point-to-multipoint connections implies a significance reduction of the IN messages exchanged (this result can be explained by considering that the number of the B-INAP messages is proportional to the number of connections that must be activated; that is 2*N in the case of

point-to-multipoint connections, N*[N-1] in the case of point-to-point, if N is the number of conferees).

As regards the B-ISDN signalling load, in Figure 7 we report the number of messages as a function of the number of involved conferees. The comparison between distributed approach and centralised one shows that the former is cost effective both for point-to-point and for point-to-multipoint connections.

This vantage is due to the saving of signalling messages exchanged at the Network Node Interface.

Another result is that the adoption of point-to-point-connections determines a better performance behaviour with respect to the point-to-multipoint ones. This can be justified by considering that, even if the number of connections to be set-up in case of PMP is lower than the PP one (2*N vs. N*[N-1], where N is the number of conferees), the signalling messages exchanged for the set-up of a point-to-multipoint connection is proportional to the number of leafs and that one signalling relationship allows to handle a single versus of the communication.
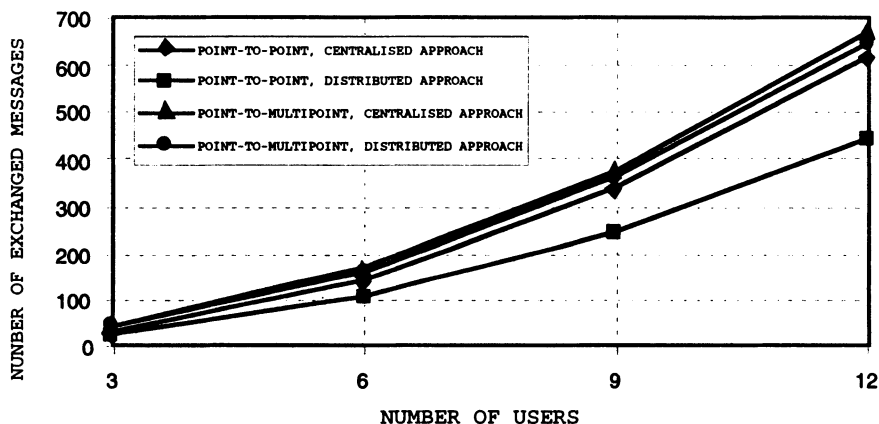
Figure 7 - Total mean B-ISDN load per SSP

To evaluate the transport resource utilisation we assumed a cost function that is linearly dependent on the mutual SSPs distance; in addition, direct connections between each couple of SSPs have been hypothesised.

Figure 8 shows the scheme of a case study network configuration. In this example six SSPs are located at the vertices of two triangles in such a way that the physical distance from a reference point in the centre of the configuration is R1 for the first three SSPs and R2 for the remaining ones. The actual links between the SSPs are not shown.

The rationale behind this choice is to describe a configuration corresponding to a first cluster of SSPs relatively close to each other, surrounded by additional SSPs located at a greater distance. By varying the above introduced parameters R1 and R2, a performance evaluation can be carried out, showing pros and cons of the

centralised approach versus the *distributed* one, with respect to the transport resources utilisation.
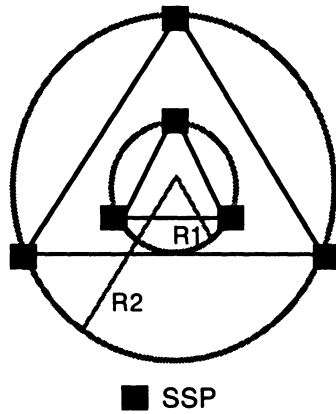

■ SSP

Figure 8 Scheme of the network configuration.

Figures 9 and 10 show the results arising from the analysis of the network configuration depicted in Figure 8, with R2/R1=100. In Figure 9, the SSP relevant to conference coordinator is located on a vertex of the internal triangle, while, in Figure 10, it corresponds to a vertex of the external triangle.
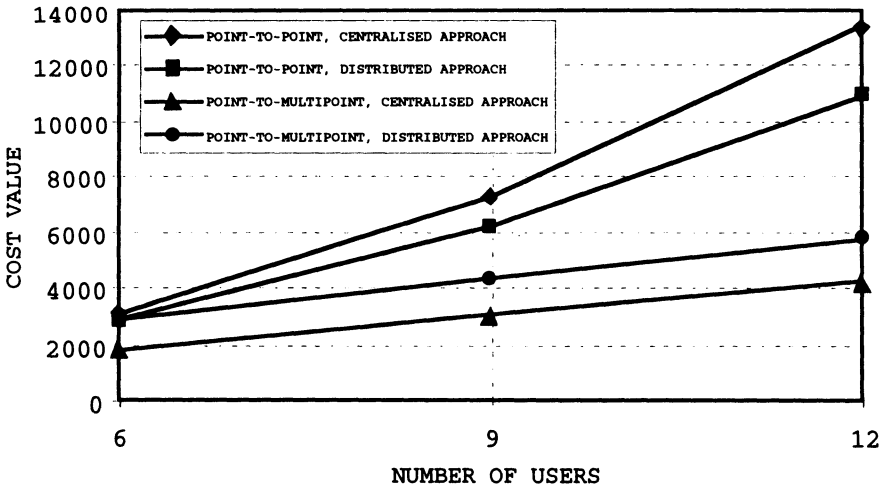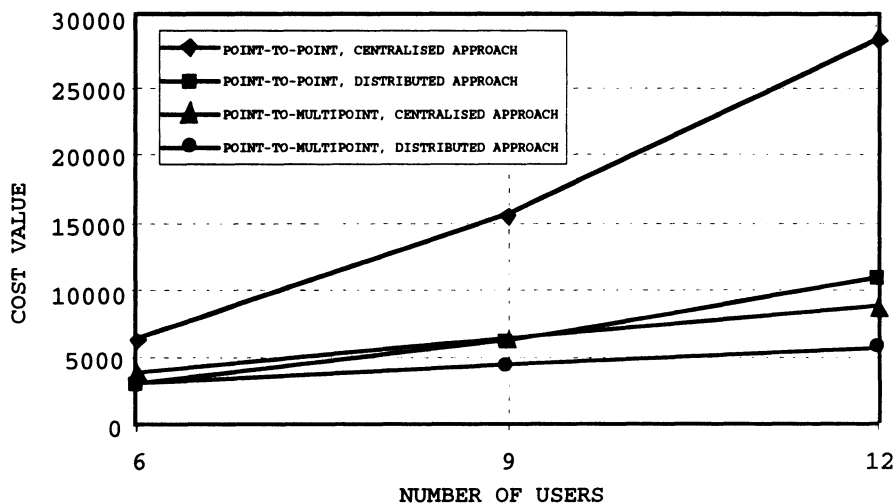

Figure 9 Cost value when the SSP relevant to the conference coordinator is located on the vertex of the internal triangle.

As it can be noted, in the case of point-to-point connections the *distributed* approach is always very cost-effective with respect to the *centralised* approach, whereas if point-to-multipoint connections are used, the *distributed* approach is convenient only if the SSP relevant to the conference coordinator is far away from the "baricentric" position of the network configuration.

Finally, the greater is the number of users, the more convenient is the use of point-to-multipoint connections.

These results can be justified by considering that the *distributed* approach allows the interconnection of users belonging to the same SSP within the SSP itself. Moreover, in the case of point-to-multipoint connections, when a user relevant to a SSP has to be added to an active conference and a leg versus that SSP already exists, no further bandwidth has to be allocated. This is because in this case the cell replication function can be used.

Figure 10 Cost value when the SSP relevant to the conference coordinator is located on the vertex of the external triangle.

3.3 Example of the model instances in the B-VC

In this section, we show an example of instances of the session model and of the service model. These examples refer to the service configuration of Figure 6a in which the *distributed* approach and point-to-point connections are assumed.

The upper part of Figure 11 shows the session instance in the SSP 1 after that the resulting connections are activated; the lower part represents the session 2 in the SSP 2. The session 1 instance models the connections between user A and users B and C, whereas the session 2 instance models the local connection between users B and C.

It is to be noted that the owner of the session 2 is the SCP since this session is the result of an "SCP-activate session" command. In both the sessions the SCP is the owner of the connections activated by "SCP-initiated call" commands. The numbers labelling the objects are assigned in accordance to the temporal activation of the network components.

Figure 12 shows the GLSC instance. This instance represents the overall service configuration, comprising the three service users and the three video information flows. Moreover, the presence of the session object allows actors and streams to be associated to the relevant session. As it can be noted, each actor can belong to one or more sessions, while each stream belongs to one session only.
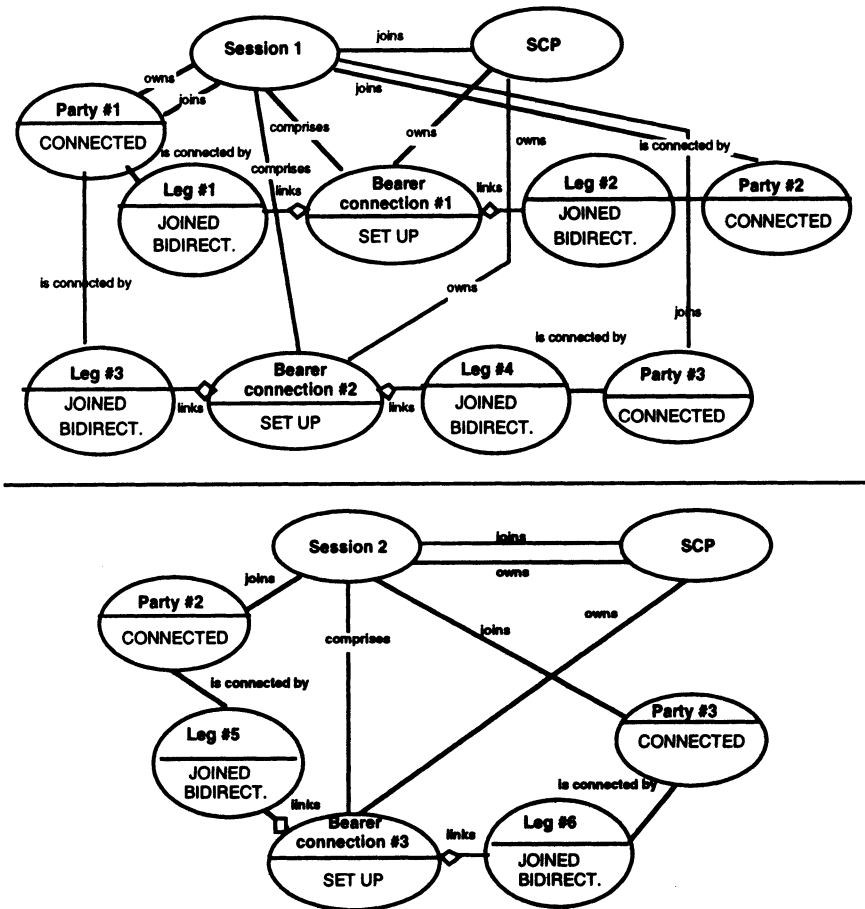

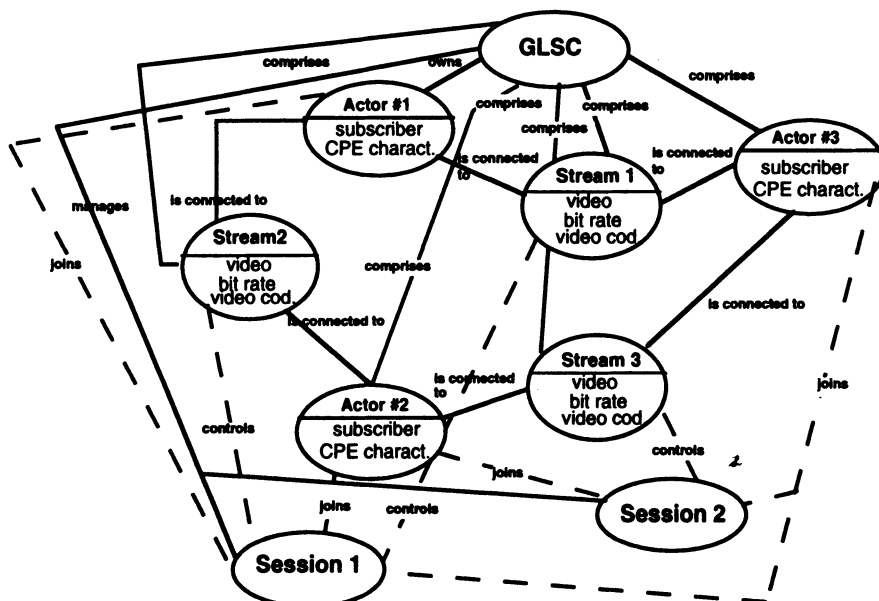**Figure 11** The session instances in SSP 1 and SSP 2.

Figure 12 The GLSC instance in the SCP.

4   CONCLUSIONS

In this paper we proposed the introduction of a new functionality in the IN architecture, called Bearer Connections Coordinator and able to realise the provisioning of multimedia-multiparty services in cooperation with the B-ISDN. The solution here presented foresees that the Bearer Connections Coordinator functionality is shared between the Service Control Function and the Service Switching Function entities. Ad hoc object models have been defined for each functional level.

This approach has been applied for the provision of the Broadband Video Conference service, which requires very advanced control capability to handle the relevant network configuration. Finally, some performance results have been discussed in order to single out the main characteristics of the presented architectural solutions.

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